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Kinoshita et al.

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(54) **LIGHTING APPARATUS, LINE SENSOR ASSEMBLY, READING APPARATUS, AND PRINTING APPARATUS**

(71) Applicant: **CANON COMPONENTS, INC.**, Kodama-gun, Saitama-ken (JP)

(72) Inventors: **Junya Kinoshita**, Saitama-ken (JP); **Junichi Kato**, Saitama-ken (JP)

(73) Assignee: **CANON COMPONENTS, INC.**, Saitama (JP)

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F21V 7/22	(2018.01)
H04N 1/028	(2006.01)
H04N 1/031	(2006.01)
H04N 1/00	(2006.01)

(52) **U.S. Cl.**

CPC ***F21S 8/02*** (2013.01); ***F21V 7/22*** (2013.01); ***F21V 19/00*** (2013.01); ***H04N 1/00557*** (2013.01); ***H04N 1/02865*** (2013.01); ***H04N 1/0312*** (2013.01)

(58) **Field of Classification Search**

CPC F21S 8/02; H04N 1/00557; H04N 1/0312; H04N 1/02865; F21V 7/22; F21V 19/00

See application file for complete search history.

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Primary Examiner — Isiaka O Akanbi
Assistant Examiner — Glenn D Zimmerman
(74) *Attorney, Agent, or Firm* — Rossi, Kimms & McDowell LLP

(57) **ABSTRACT**

There is provided with a lighting apparatus. An elongated first light emission unit and an elongated second light emission unit each extend in a longer side direction and a shorter side direction. The first light emission unit and the second light emission unit have respective end portions in the longer side direction that are connected to each other via a restricting mechanism having a shape that restricts relative movement of the first and second light emission units in the shorter side direction.

12 Claims, 3 Drawing Sheets

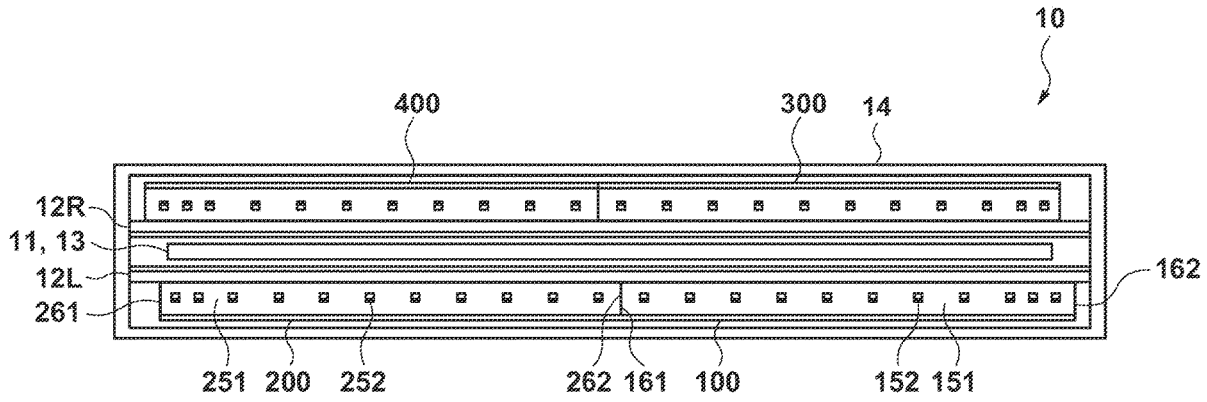

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FIG. 1

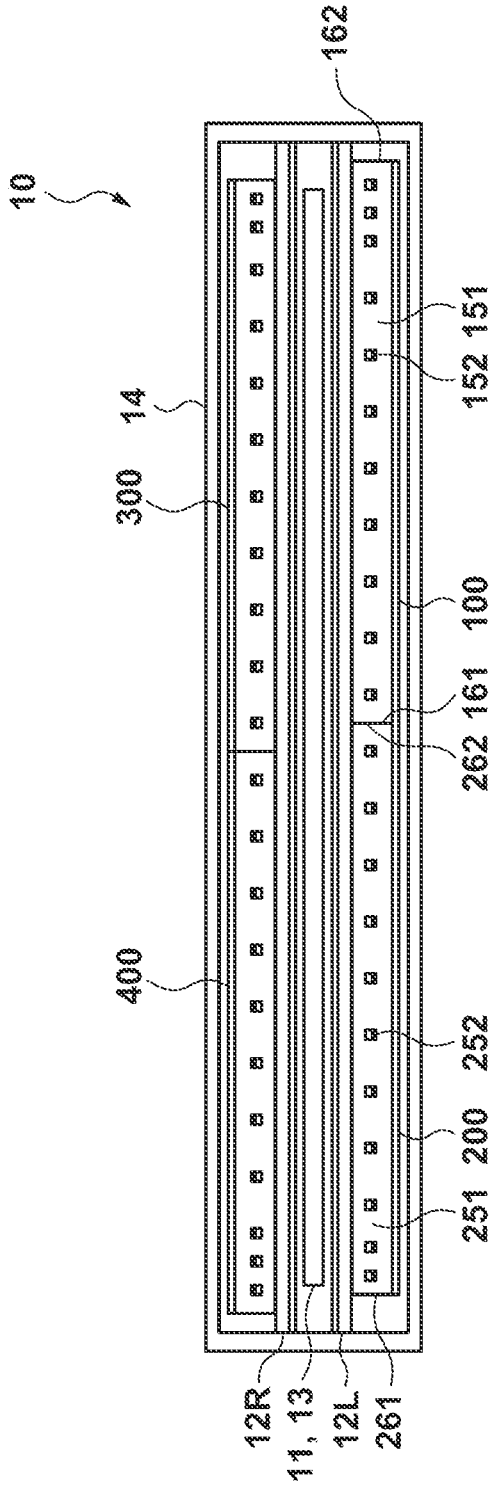

162
10
151
152
14
300
100
161
262
400
252
200
251
12R
11, 13
12L
261

FIG. 2

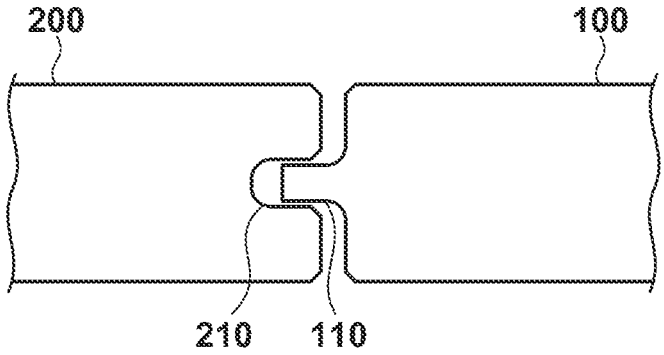


FIG. 3A

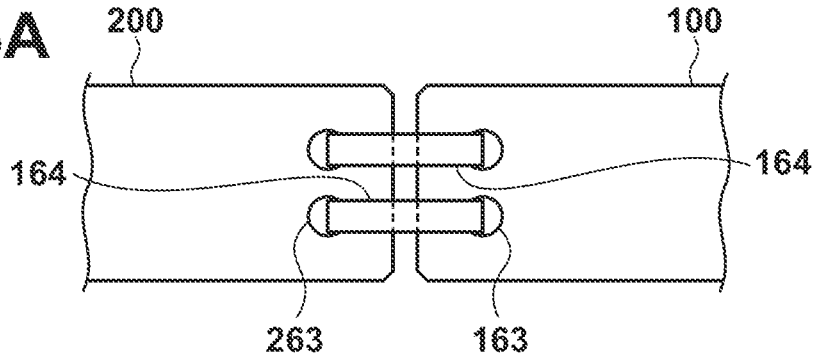


FIG. 3B

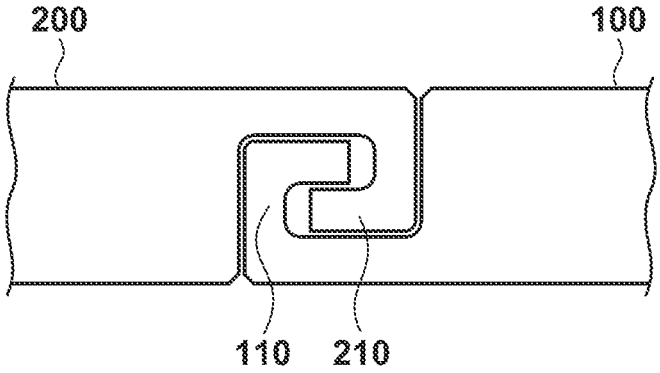


FIG. 3C

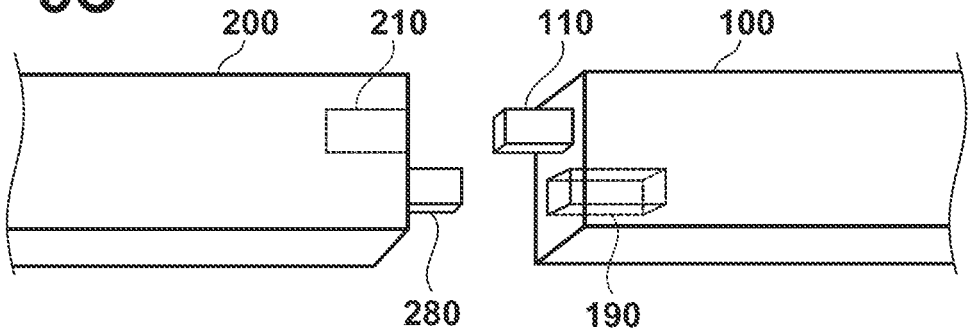


FIG. 4

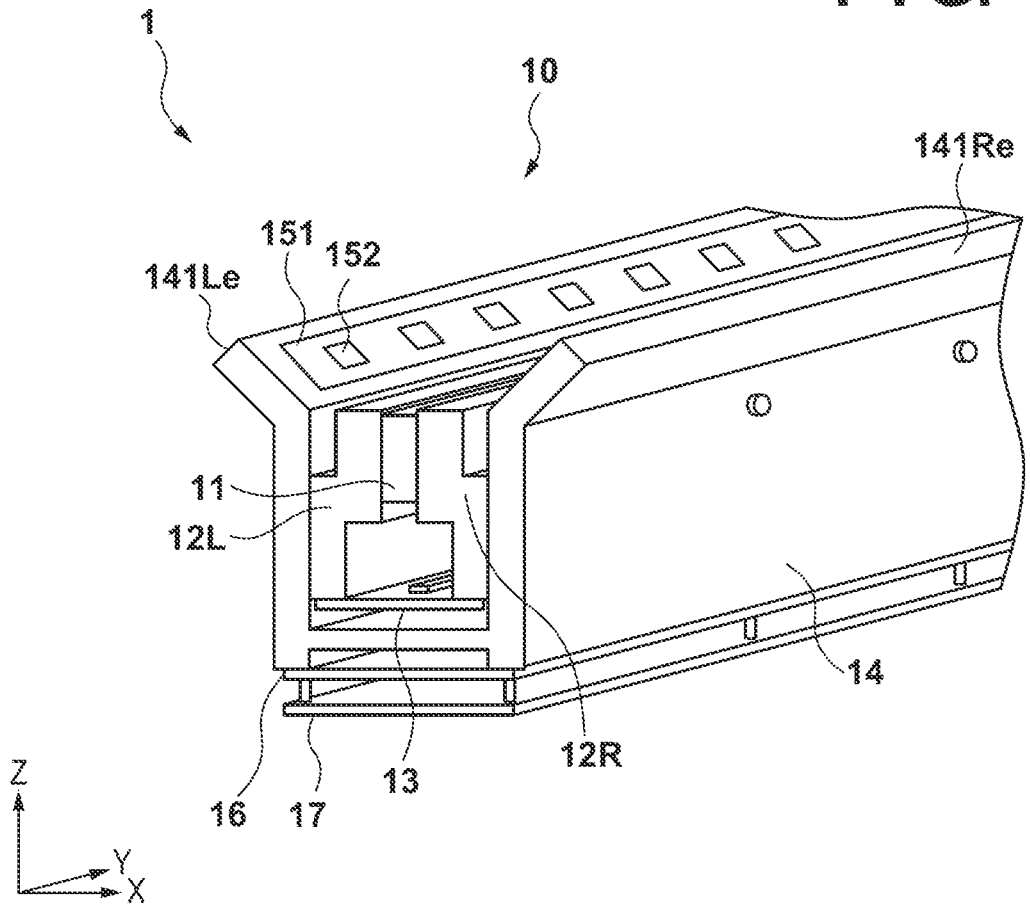
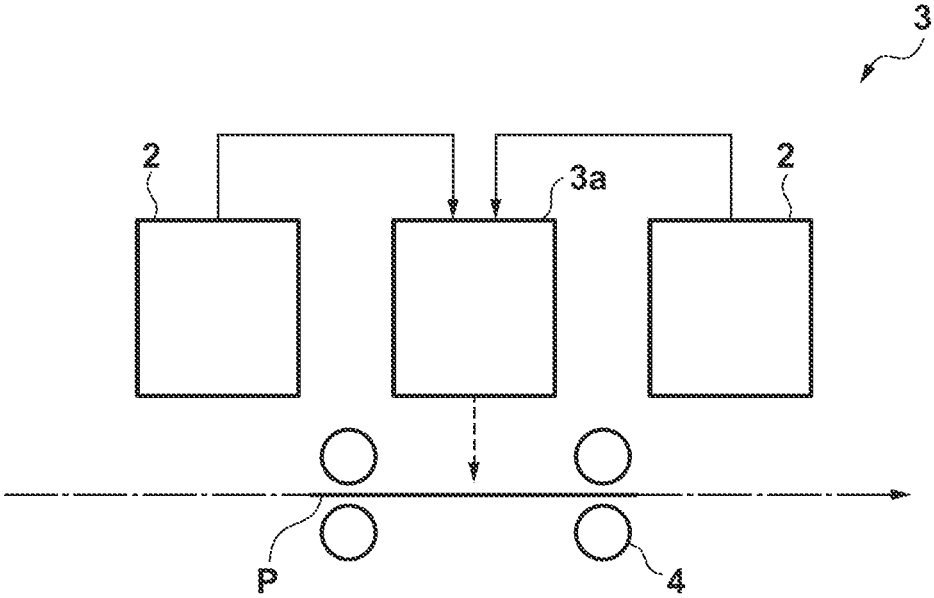


FIG. 5



LIGHTING APPARATUS, LINE SENSOR ASSEMBLY, READING APPARATUS, AND PRINTING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a lighting apparatus, a line sensor assembly, a reading apparatus, and a printing apparatus.

Description of the Related Art

Optical reading apparatuses that read an object by irradiating light from a light source portion onto the object, condensing light reflected by the object and guiding the reflected light to a sensor are known. For a lighting apparatus that is used as the light source portion in the case of using a line sensor as the sensor, an elongated light source portion is used, in order to irradiate light onto a linear area of an object that is conveyed. Japanese Patent Laid-Open No. 2015-53190 discloses an elongated LED lighting apparatus having two LED substrates provided in series.

SUMMARY OF THE INVENTION

According to an embodiment of the present invention, a lighting apparatus comprising: an elongated first light emission unit and an elongated second light emission unit each extend in a longer side direction and a shorter side direction, wherein the first light emission unit and the second light emission unit have respective end portions in the longer side direction that are connected to each other via a restricting mechanism having a shape that restricts relative movement of the first and second light emission units in the shorter side direction.

According to another embodiment of the present invention, a lighting apparatus comprising: an elongated first light emission unit and an elongated second light emission unit that extend in a longer side direction and a shorter side direction, wherein the first light emission unit and the second light emission unit are connected to each other at respective end portions in the longer side direction, and each of the first light emission unit and the second light emission unit has a main surface with a shape for interconnection, wherein the shape for interconnection connects the first light emission unit and the second light emission unit and restricts relative movement in the shorter side direction.

According to still another embodiment of the present invention, a lighting apparatus comprising: an elongated first light emission unit and an elongated second light emission unit that extends in a longer side direction and a shorter side direction, wherein the first light emission unit and the second light emission unit are connected to each other at respective end portions in the longer side direction, and the first light emission unit and the second light emission unit have respective end portion surfaces opposing with each other, wherein each of the end portion surfaces has a shape for interconnection, and the shape for interconnection connects the first light emission unit and the second light emission unit and restricts relative movement in the shorter side direction.

According to yet another embodiment of the present invention, a printing apparatus comprising: a reading sensor including a line sensor configured to detect light; and a printer configured to print on a medium, wherein the printer is further configured to perform printing on the medium that has undergone reading by the reading sensor.

Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top view of a lighting apparatus according to one embodiment.

FIG. **2** is a top view of connecting portions of light emission units according to one embodiment.

FIGS. **3**A to **3**C are top views of connecting portions of light emission units according to one embodiment.

FIG. **4** is a perspective view of a line sensor assembly according to one embodiment.

FIG. **5** is a schematic view of a printing apparatus according to one embodiment.

DESCRIPTION OF THE EMBODIMENTS

Reading apparatuses are required to irradiate light onto an object such that a desired illumination distribution is obtained. On the other hand, in the case where the technology described in Japanese Patent Laid-Open No. 2015-53190 relating to building lighting is applied to a reading apparatus, there is a problem in that the desired illumination distribution is not obtained, due to positional shift between a plurality of light source portions such as LED substrates. It is thought that positional shift between the plurality of light source portions, particularly in a direction orthogonal to the longer side direction, greatly affects the illumination distribution.

An embodiment of the present invention provides a lighting apparatus with which a desired illumination distribution can be obtained by combining two or more light emission units.

A lighting apparatus **10** according to one embodiment of the present invention will be described with reference to FIG. **1**. The lighting apparatus **10** according to one embodiment of the present invention includes an elongated first light emission unit **100** and an elongated second light emission unit **200**.

The first light emission unit **100** and the second light emission unit **200** each have a main surface that extends in an X direction, which is the longer side direction, and a Y direction, which is the shorter side direction (e.g., rectangular, parallelogram, etc.). The main surface indicates a principle surface of the light emission units. In one embodiment, the light emission units have shapes with thickness that extend in a tabular manner, and in this case a surface that extends in a tabular manner (front surface or back surface) can be referred to as a main surface. In one embodiment, the light emission units include a tabular substrate and a light source provided on the substrate. In this case, a substrate surface (front surface or back surface) can be referred to as a main surface. The longer side direction of the substrate surface corresponds in the X direction, and the shorter side direction of the substrate surface (direction perpendicular to the longer side direction) corresponds in the Y direction. The surface of the light emission units on which the light source is provided can also be referred to as a main surface. Furthermore, the light emission units can be provided on a placement surface of a casing, and the surface of the light emission units along this placement surface can also be referred to a main surface. FIG. **1** shows an external view of

the first light emission unit **100** and the second light emission unit **200** as seen from the main surface side.

End portions of the first light emission unit **100** and the second light emission unit **200** in the longer side direction are connected to each other. In FIG. **1**, the first light emission unit **100** and the second light emission unit **200** are connected in series, and are aligned in a straight line. Also, the first light emission unit **100** has a first end portion **161** and a second end portion **162**, which are end portions of the first light emission unit **100** in the longer side direction. Also, the second light emission unit **200** has a first end portion **261** and a second end portion **262**, which are end portions of the second light emission unit **200** in the longer side direction. In the example in FIG. **1**, the first end portion **161** of the first light emission unit **100** is connected to the second end portion **262** of the second light emission unit **200**.

The first light emission unit **100** and the second light emission unit **200** are connected to each other via a restricting mechanism. The restricting mechanism has a shape that restricts relative movement of the first light emission unit **100** and the second light emission unit **200** in the shorter side direction (Y direction). For example, the restricting mechanism is able to fix the relative positional relationship of the first light emission unit **100** and the second light emission unit **200**, such that the first light emission unit **100** and the second light emission unit **200** do not move relatively. In one embodiment, the first light emission unit **100** and the second light emission unit **200** are substantially flat members having a predetermined length (length in the longer side direction), a predetermined width (length in the shorter side direction) and a predetermined thickness. In such an embodiment, the restricting mechanism is able to restrict relative movement of the first light emission unit **100** and the second light emission unit **200** in the width direction, for example. In one embodiment, the restricting mechanism is able to fix the relative positional relationship, such that the first light emission unit **100** and the second light emission unit **200** contact each other.

Hereinafter, an example of the restricting mechanism will be described, with reference to FIG. **2**. FIG. **2** is an external view of connecting portions of the first light emission unit **100** and the second light emission unit **200** in one embodiment from the main surface side. The restricting mechanism shown in FIG. **2** is formed by a protruding portion **110** that is formed on the first end portion **161** of the first light emission unit **100**, and an engaging portion **210** that is formed in the second end portion **262** of the second light emission unit **200** and engages the protruding portion **110**. The protruding portion **110** and the engaging portion **210** can be constituted such that, when engaged or when moving relative to each other in a direction orthogonal to the longer side direction, the side surface of the protruding portion **110** contacts the side surface of the engaging portion **210**. For example, the protruding portion **110** and the engaging portion **210** can be constituted such that, when engaged, the side surfaces in the shorter side direction face each other. Also, the protruding portion **110** and the engaging portion **210** can be constituted such that, when engaged or when moving relative to each other in a direction orthogonal to the longer side direction, the side surfaces in the shorter side direction contact each other. According to such a restricting mechanism, positional shift in the shorter side direction can be suppressed, when connecting the end portions of the first light emission unit **100** and the second light emission unit **200** to each other. In FIG. **2**, a left-right direction corresponds in the longer side direction (length direction), an up-down direction corresponds in the shorter side direction (width direction), and a front-back direction corresponds in the thickness direction. In the case of using such a configuration, an adhesive need not be used in connecting the first light emission unit **100** and the second light emission unit **200**, and positional shift of the light emission units can be suppressed even in this case. Note that, even in the case where the light emission units shift at an angle, it can be said that there is shift in the Y direction in the case where a Y component exists when the shift direction is broken down into X and Y components. That is, in one embodiment, the restricting mechanism is able to suppress positional shift (relative movement) of the light emission units in directions that include a Y direction (shorter side direction) component.

In this way, in one embodiment, the first light emission unit **100** and the second light emission unit **200** respectively have shapes (e.g., the protruding portion **110** and the engaging portion **210**) on main surfaces. Relative movement in the shorter side direction (Y direction) is restricted as a result of such shapes, that is, by the light emission units being connected via main surface end portions that are not straight. In one example, the end portion of the main surface at the connecting portion of the first light emission unit **100** has a protruding shape, and the end portion of the main surface at the connecting portion of the second light emission unit **200** has a shape that engages the protruding shape of the first light emission unit **100**.

Another example of the restricting mechanism will be described, with reference to FIG. **3**B. FIG. **3**B is an external view of the connecting portions of the first light emission unit **100** and the second light emission unit **200** in another embodiment from the main surface side. In FIG. **3**B, the protruding portion **110** and the engaging portion **210** that constitute the restricting mechanism each have a key-like shape, and are engaging each other. In this example, the protruding portion **110** and the engaging portion **210**, when engaged, contact each other at side surfaces in the shorter side direction, and also contact each other at side surfaces in the longer side direction. According to such a configuration, positional shift in the shorter side direction can be suppressed, and positional shift in the longer side direction can also be suppressed, when connecting end portions of the first light emission unit **100** and the second light emission unit **200** with each other.

Another example of the restricting mechanism will be described, with reference to FIG. **3**C. FIG. **3**B shows the connecting portions of the first light emission unit **100** and the second light emission unit **200** in another embodiment. Note that FIG. **3**C shows the connecting portions before being connected to each other. In FIG. **3**C, the protruding portion **110** constituting the restricting mechanism is a raised portion that has a shape protruding from the end portion opposing surface of the first light emission unit **100** at the connecting portion. Also, the engaging portion **210** constituting the restricting mechanism is a recessed portion that has a shape recessed from the end portion opposing surface of the second light emission unit **200** at the connecting portion, and engages the raised portion of the first light emission unit **100**. That is, the first light emission unit **100** and the second light emission unit **200** respectively have shapes (e.g., the protruding portion **110** and the engaging portion **210**) in end portion opposing surfaces. Relative movement in the shorter side direction (Y direction) is restricted as a result of such shapes, that is, by the light emission units being connected via the end portion opposing surfaces that are not flat. As shown in FIG. **3**C, the second light emission unit **200** may further have a raised portion **280** on the end portion opposing surface, and the first light

emission unit **100** may further have a recessed portion **190** that engages the raised portion **280** in the end portion opposing surface.

A further example of the restricting mechanism will be described, with reference to FIG. **3**A. FIG. **3**A is an external view of the connecting portions of the first light emission unit **100** and the second light emission unit **200** in the further embodiment from the main surface side. In FIG. **3**A, the restricting mechanism is formed by an interconnecting portion **164**, a connecting portion **163** and a connecting portion **263**. The interconnecting portion **164** is an interconnecting member that interconnects the first light emission unit **100** and the second light emission unit **200**. The connecting portion **163** is provided in the first end portion **161** of the first light emission unit **100**, and connects to the interconnecting portion **164**. The connecting portion **263** is provided in the end portion of the second light emission unit **200**, and connects to the interconnecting portion **164**.

In one embodiment, as shown in FIG. **3**A, the connecting portions **163** and **263** are latching holes provided in the end portions of the first light emission unit **100** and the second light emission unit **200**. End portions of the interconnecting portion **164** can be inserted into the connecting portions **163** and **263** and fixed. According to such a configuration, the distance between the connecting portions **163** and **263** can be fixed. Accordingly, relative positional shift can be suppressed, by interconnecting the first light emission unit **100** and the second light emission unit **200** using the interconnecting portion **164**, such that the first end portion **161** and the second end portion **262** contact each other.

Although, in FIG. **3**A, there are two each of the interconnecting portion **164** and the connecting portions **163** and **263**, the numbers thereof are not particularly limited. Also, the method of connecting the interconnecting portion **164** to the connecting portions **163** and **263** is also not particularly limited. For example, the interconnecting portion **164** may be a band-like metal strip, and may be another material or have another shape.

The specific configuration of the first light emission unit **100** and the second light emission unit **200** is not particularly limited. For example, the first light emission unit **100** and the second light emission unit **200** may be the same light emission unit. Also, the length in the longer side direction may differ between the first light emission unit **100** and the second light emission unit **200**. By providing and connecting the light emission units of different lengths, light emission portions having various lengths can be realized. In one embodiment, in order to facilitate connection, the end face of the first end portion **161** of the first light emission unit **100** is the same size as the end face in the second end portion **262** of the second light emission unit **200**.

In one embodiment, the elongated first light emission unit **100** includes an elongated first substrate **151** and a first light source group **152** provided on a substrate of the first substrate **151**. Also, the elongated second light emission unit **200** includes an elongated second substrate **251** and a second light source group **252** provided on a substrate of the second substrate **251**. Here, the first substrate **151** and the second substrate **251** can be connected flush, such that end portions in the longer side direction face each other. For example, the first substrate **151** and the second substrate **251** can be connected such that the surfaces of the substrates are aligned flush with each other. The first substrate **151** and the second substrate **251** can also be disposed with supporting members flush.

In the example in FIG. **1**, the first substrate **151** and the second substrate **251** are connected such that end portions in the longer side direction face each other, via the restricting mechanism. For example, the first substrate **151** can have the protruding portion **110**, and the second substrate **251** can have the engaging portion **210**. Also, the first substrate **151** may have the connecting portion **163**, and the second substrate **251** may have the connecting portion **263**. In such a configuration, the restricting mechanism is able to restrict relative movement between the first substrate **151** and the second substrate **251** in the shorter side direction, along the first substrate **151** and the second substrate **251**.

The first light source group **152** and the second light source group **252** are provided with a plurality of light sources. The type of light source that the first light source group **152** and the second light source group **252** are provided with is not particularly limited. For example, the light source may be an LED (light emitting diode), or may be other light emitting elements. In one embodiment, the first light source group **152** can be an LED array in which a plurality of LEDs (light emitting diodes) are arrayed in the longer side direction of the first substrate **151**. Also, the second light source group **252** may be an LED array in which a plurality of LEDs are arrayed in the longer side direction of the second substrate **251**.

In one embodiment, in the first light emission unit **100**, the light emission amount of the second end portion **162**, which is on the opposite end portion side to the first end portion **161**, is larger than the light emission amount of the first end portion **161**, which is on the end portion side that is connected to the second light emission unit **200**. The second light emission unit **200** exists on the first end portion **161** side, but since there is no adjacent light emission unit on the second end portion **162** side, there tends to be a deficiency in the amount of projected light on the second end portion **162** side. On the other hand, realizing a uniform amount of projected light across the entirety in the longer side direction is facilitated, by increasing the light emission amount on the second end portion **162** side. As a specific example, such a configuration can be realized by increasing the disposition density of the light sources on the second end portion **162** side to be higher than on the first end portion **161** side. For example, in the example in FIG. **1** using LEDs as the light source, the disposition density of the LEDs on the second end portion **162** side is higher than on the first end portion **161** side. Similarly, the second light emission unit **200** can also be configured such that the first end portion **261** side on the opposite side to the second end portion **262** has a larger light emission amount than the second end portion **262** that is connected to the first light emission unit **100**.

In the lighting apparatus according to the present embodiment, relative positional shift between the first light emission unit **100** and the second light emission unit **200** in a direction orthogonal to the longer side direction can be suppressed. When arranging two or more light emission units in a line to produce a more elongated lighting apparatus, the distribution of the amount of light projected onto an object that is irradiated can thus be approximated to a desired distribution. Also, by using the restricting mechanism, accurately arranging the first light emission unit **100** and the second light emission unit **200** in a line in the longer side direction is facilitated. For example, as shown in FIG. **1**, in one embodiment, the lighting apparatus has a structure in which the first light emission unit **100** and the second light emission unit **200** are provided in a casing (outer side supporting member **14**). Such a lighting apparatus can be manufactured by arranging the first light emission unit **100** and the second light emission unit **200** in a line on the surface of the casing. At this time, by using the restricting

mechanism, disposition of the first light emission unit **100** and the second light emission unit **200** so as to not shift a direction orthogonal to the longer side direction is facilitated. Note that the first light emission unit **100** and the second light emission unit **200** can further be fixed to the casing using a fixed member such as a screw.

Here, a lighting apparatus including two light emission units was described. However, the number of light emission units that are included in the lighting apparatus is not restricted. For example, as shown in FIG. **1**, the lighting apparatus may include a third light emission unit **300** and a fourth light emission unit **400**, in addition to the first light emission unit **100** and the second light emission unit **200**. Here, the third light emission unit **300** and the fourth light emission unit **400** can have a similar configuration to the first light emission unit **100** and the second light emission unit **200**. For example, the end portions of the third light emission unit **300** and the fourth light emission unit **400** in the longer side direction may be connected to each other via a restricting mechanism that restricts relative movement in a direction orthogonal to the longer side direction. Also, the lighting apparatus may have a structure in which three or more light emission units are connected. In this case, the three or more units may be respectively connected via a restricting mechanism that restricts relative movement in a direction orthogonal to the longer side direction.

Such a lighting apparatus can be used as a lighting apparatus for a line sensor assembly. Hereinafter, a line sensor assembly that includes the lighting apparatus according to the present embodiment will be described. The line sensor assembly according to one embodiment includes a casing, the lighting apparatus according to the present embodiment, a lens array, and a line sensor. Hereinafter, an example of the line sensor assembly will be described, with reference to FIG. **4**. Note that FIG. **1** corresponds to a top view of the line sensor assembly shown in FIG. **4**.

FIG. **4** is a perspective view for illustrating the structure of a line sensor assembly **1** according to one embodiment. In order to facilitate an understanding of the structure, an X-axis, a Y-axis and a Z-axis that are orthogonal to each other are shown in the diagram. Hereinafter, the X-axis direction may be referred to as the direction in which an inner side supporting member **12** sandwiches a rod lens array **11**, or simply as the sandwiching direction. Also, the Y-axis direction may be referred to as the direction of the array of the rod lens array **11**, or simply as the array direction. Furthermore, the Z-axis direction may be referred to as the direction of the optic axis of the rod lens array **11**, or simply as the optic axis direction. Also, the line sensor assembly **1** has an elongated structure extending in the Y direction.

Note that, herein, expressions indicating directions are used for indicating relative positional relationships. For example, expressions such as "right" or "right side" corresponds to a +X direction, and expressions such as "left" or "left side" corresponds to a −X direction. Also, for example, expressions such as "up" or "upward" corresponds to a +Z direction, and expressions such as "down" or "downward" corresponds to a −Z direction.

The line sensor assembly **1** includes the outer side supporting member **14**. The outer side supporting member **14** has an elongated shape extending in the array direction, and is disposed so as to sandwich two inner side supporting members **12**L and **12**R, which will be discussed later, and supports the two inner side supporting members **12**L and **12**R. In one embodiment, the outer side supporting member **14** corresponds to the casing of the line sensor assembly **1**, and each element is fixed directly or indirectly to the outer side supporting member **14**. In the example in FIG. **4**, the outer side supporting member **14** has a mirror-image symmetrical shape.

The lighting apparatus **10** that is included in the line sensor assembly **1** irradiates light onto an object to be measured. The configuration of the lighting apparatus **10** is as already been described. The lighting apparatus **10** is elongated, and can be disposed on at least one elongated outer side supporting member **14**. FIG. **4** shows such an example, with two lighting apparatuses **10** being fixed to sloping surfaces respectively formed on sloping portions **141**Le and **141**Re of the outer side supporting member **14**. Adopting such a configuration enables the elongated lighting apparatus **10** to irradiate light onto an object (not shown) that can be placed upward of the rod lens array **11**. Also, a light transmissive plate material (not shown) such as a glass plate can be provided between the object and the line sensor assembly **1**. The lighting apparatus **10** can be provided upward of the rod lens array **11**. A shadow is thereby prevented from occurring when the lighting apparatus **10** irradiates light onto the object.

The lens array that is included in the line sensor assembly **1** condenses the light irradiated toward the object from the lighting apparatus **10**, and guides the light to a line sensor **13**. In the example in FIG. **4**, the rod lens array **11** is used as a lens array. The line sensor assembly **1** is able to determine the amount or color of the light from the object, by detecting the light condensed by the rod lens array **11**. For example, the color, reflectance or transmittance of the object can be measured by detecting the light reflected by the object or the light transmitted by the object. As an example, the line sensor assembly **1** is able to read an image printed on a printing medium (e.g., paper).

The rod lens array **11** includes a plurality of rod lenses arrayed in a predetermined direction (Y direction in the present embodiment). The individual rod lenses are disposed in a line with the light incident surfaces facing in the Z direction, such that the optic axes are parallel. That is, the rod lens array **11** has an elongated structure extending in the array direction. Adopting such a configuration enables measurement to be performed at one time on a long linear area on the object that passes upward of the rod lens array **11**. Although the rod lenses are disposed in one row in the present embodiment, two or more rows of rod lenses may be arrayed. Also, although not illustrated, the rod lens array **11** may have a frame within which the arrayed rod lenses are housed.

The line sensor **13** that is included in the line sensor assembly **1** detects the light condensed by the lens array. That is, the line sensor **13** is irradiated by the lighting apparatus **10**, and is able to detect light reflected by the object or light transmitted by the object. The line sensor **13** is fixed on the optical path of the rod lens array **11**, so as to receive the light condensed by the rod lens array **11**. In the present embodiment, the line sensor **13** has a configuration that enables light condensed by the elongated rod lens array **11** to be detected at one time. In the present embodiment, the line sensor **13** has an elongated structure that extends in the array direction (Y direction) of the rod lens array **11**. For example, the line sensor **13** can have a structure in which a plurality of photoelectric conversion elements (e.g., photodiodes) are arrayed in the array direction (Y direction) of the rod lens array **11**. A CCD or CMOS sensor, for example, can be used as the line sensor **13**. The configuration of the line sensor **13** is not particularly limited, and an area sensor in which a plurality of photoelectric conversion elements are

arrayed in a matrix or houndstooth pattern, for example, may be used. Also, light detection elements such as PIN sensors or MIS sensors may be used as the photoelectric conversion elements, instead of photodiodes.

In the example in FIG. **4**, the rod lens array **11** is fixed so to be sandwiched by the two inner side supporting members **12**L and **12**R. Also, the line sensor **13** is fixed directly or indirectly to at least one of the two inner side supporting members **12**L and **12**R. The two inner side supporting members **12**L and **12**R each have an elongated structure extending in the array direction. The outer side supporting member **14** supports the two inner side supporting members **12**L and **12**R, and the rod lens array **11** and the line sensor **13** are thus also fixed to the outer side supporting member **14**, which is the casing.

The line sensor assembly **1** may be provided with other configurations. For example, the line sensor assembly **1** shown in FIG. **4** has mounting substrates **16** and **17** that transmit the results of detection by the line sensor **13** externally and supply power to the line sensor **13** or the lighting apparatus **10**.

The line sensor assembly **1** according to the present embodiment can be used as follows. For example, while the object is being relatively scanned with respect to the line sensor assembly **1**, the lighting apparatus **10** irradiates the object. Reflected light from the object is condensed by the rod lens array **11** and detected by the line sensor **13**. Thereafter, the mounting substrates **16** and **17** generate signals that are based on the results of detection by the line sensor **13**, and output the signals externally. The type of signal that is output externally is not particularly limited, and image data showing an image of the object (image on a printing medium, etc.), a signal indicating the shift of the detection result from a reference value, and the like are given as examples. As a specific example, reading of a printing medium can be performed, by providing a detection surface (e.g., surface of light transmissive plate material) upward of the line sensor assembly **1**, and the line sensor **13** detecting light while moving the printing medium over the detection surface. In the example in FIG. **4**, the line sensor **13** detects reflected light from the object, but the line sensor **13** may detect light irradiated onto the object from the lighting apparatus **10** and transmitted by the object.

Such a line sensor assembly can be used as a constituent element of a reading apparatus or a printing apparatus. FIG. **5** shows an example of a reading apparatus **2** that includes the line sensor assembly **1** and a printing apparatus **3**.

The reading apparatus **2** includes the line sensor assembly **1** and an output unit that outputs read data obtained by the line sensor assembly **1**. The output unit is able to generate signals that are based on the results of detection by the line sensor **13**, and output read data externally. For example, the abovementioned mounting substrates **16** and **17** can be used as the output unit.

The printing apparatus **3** includes the reading apparatus **2**, a printing unit **3***a* that prints onto media based on the result of reading by the reading apparatus **2**, and a conveying unit that conveys the media. The printing unit **3***a* is able print text, images or the like on media P (e.g., paper) with a suitable method such as an inkjet method or an electrophotographic method. Also, conveyance rollers **4** that convey the media from upstream to downstream can be used as the conveying unit. Also, in one embodiment, the conveying unit may move the printing unit **3***a* relative to the media, or may move the both the media and the printing unit **3***a*. In one embodiment, the printing apparatus **3** is able to perform copy processing, and, in this case, the printing unit **3***a* prints images read by the reading apparatus **2** onto the media. Also, in one embodiment, the printing apparatus **3** is able to perform feedback control. For example, the reading apparatus **2** is able to perform reading on media that has undergone printing by the printing unit **3***a*, and transmit read data to the printing apparatus **3**. Based on this read data, the printing apparatus **3** is able to check the printing state onto the media, and is able to control the printing parameters at the time of the next printing.

As a specific example, a configuration will be described in which the reading apparatus **2** performs reading on the media P, and the printing unit **3***a* prints onto the media P that has been read by the reading apparatus **2**, based on the read data. For example, the printing position onto the media P by the printing unit **3***a* can be controlled, based on the result of reading the media P by the reading apparatus **2**. Also, the parameters for printing onto the media P by the printing unit **3***a* can be controlled, based on the result of reading the media P by the reading apparatus **2**. Furthermore, the printing unit **3***a* is able to print information (e.g., text information or graphic information) that is based on the result of reading the media P by the reading apparatus **2** onto the media P.

For example, the reading apparatus **2** is able to read a mark given to the media P. In one embodiment, an alignment mark to be used in positioning at the time of printing is given in advance to the media P. The reading apparatus **2** may, by reading the alignment mark, detect a shift of the media P from a reference position based on the reading position thereof, and transmit the detection result to the printing unit **3***a* as read data, for example. The printing unit **3***a* is able to print text, images or the like at a more accurate position, by adjusting the printing position based on the shift of the media P from the reference position. According to the present embodiment, in the case where printing is performed on both sides of the media P, for example, the printing positions on the front side and the back side can be more accurately aligned. Also, because printing of text, images or the like in each process can be performed at a more accurate position, in the case of printing in multi-layers on the media P with a plurality of processes (multi-layered printing), for example, the overlapping of text, images or the like printed in each process can be prevented. Note that the shape of the alignment mark may be a cross (+) mark, a circle (○) mark or the like, for example.

As another example of the mark, the media P may have a barcode. In this case, the media P can have a barcode that differs for every type (size, material, color, etc.) thereof. The printing unit **3***a* is able to perform printing according to the type of media P, as a result of the reading apparatus **2** reading the barcode and transmitting information on the type of media P to the printing unit **3***a* as read data. For example, the printing unit **3***a* may control the printing parameters at the time of printing (depth, color, etc. of text, images, etc.) or the like according to the type of media P. Also, for example, the printing unit **3***a* may print information such as a product name or the like onto the media P according to the type of media P. Furthermore, the printing unit **3***a* may print information corresponding to the barcode onto the media P. As an example, the printing unit **3***a* is able to print a product name corresponding to a barcode onto paper on which the barcode is printed.

The reading apparatus **2** may read an entry column (blank column) provided on the media P as another example of a mark. In one embodiment, the reading apparatus **2** reads the position of the entry column provided on the media P, and transmits the read data to the printing unit **3***a*. The printing

unit **3***a* prints text so as to fit within the entry column of the media P, based on the read data. According to such a configuration, the printing unit **3***a* is able to print text and the like in alignment with the position of an entry column on the media P, and thus printed text can be prevented from extending outside the entry column.

As another example, the reading apparatus **2** may read information relating to the media P itself, such as position information of the media or color information of the media. As information relating to the media P itself, position, width, angle or color of an edge of the media P is given as an example. In one embodiment, the reading apparatus **2** reads a leading edge position of the media P in the conveyance direction, and transmits the read data to the printing unit **3***a*. The printing unit **3***a* is able to print images or the like at a more accurate position, by controlling the time at which printing of text, images or the like is started on the media P, based on the read data. Also, the printing unit **3***a* is able to perform so-called borderless printing by starting printing of text, images or the like from the leading edge position of the media P. In the case of performing borderless printing, the reading apparatus **2** may read both side edge positions and a trailing edge position, rather than only the leading edge position of the media P. Borderless printing can thereby be performed more accurately. Also, in one embodiment, the reading apparatus **2** reads a fold, a missing part or the like (hereinafter, fold or the like) of the media P, that is, a difference from the original shape of the media P, and transmits the reading result to the printing unit **3***a* as read data. The printing unit **3***a* is able to print a symbol indicating that the media P is a defect, in the case where there is a fold or the like in the media P. In the case where printing is performed by the printing unit **3***a* on a large volume of media P, a worker is thereby able to easily identify defects among the large volume of media P. Furthermore, in one embodiment, the reading apparatus **2** determines the type (size, material, color, etc.) of the media P, and transmits the result to the printing unit **3***a* as read data. The printing unit **3***a* is able to perform print according to the type of media P, based on the read data. In the case where the media P is paper, the printing unit **3***a* is able to perform printing after adjusting the hue and the like of the text, images or the like according to the paper quality, or print patterns that are suited to the color of the paper.

Note that the reading apparatus **2** and the printing apparatus **3** are capable of communicating with each other by cable connection, wireless connection or the like. Also, the media P may be paper in sheet form or paper in continuous form.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2017-152693, filed Aug. 7, 2017, and Japanese Patent Application No. 2018-141566, filed Jul. 27, 2018 which are hereby incorporated by reference herein in their entirety.

What is claimed is:

1. A line sensor apparatus comprising:
a casing;
a lighting apparatus;
a lens array configured to condense light irradiated toward an object from the lighting apparatus; and
a line sensor configured to detect the light condensed by the lens array,
wherein the lighting apparatus has an elongated first light emission unit and an elongated second light emission unit each extending in a longer side direction and a shorter side direction, and
wherein the first light emission unit and the second light emission unit have respective end portions in the longer side direction that are connected to each other via a restricting mechanism having a shape that restricts relative movement of the first and second light emission units in the shorter side direction.

2. The line sensor apparatus according to claim **1**,
wherein the restricting mechanism includes:
a protruding portion formed on the end portion of the first light emission unit; and
an engaging portion formed on the end portion of the second light emission unit which is engaged with the protruding portion.

3. The line sensor apparatus according to claim **1**,
wherein the restricting mechanism includes:
an interconnecting portion which connects the first light emission unit and the second light emission unit; and
connecting portions provided on the end portions of the first light emission unit and the second light emission unit which connect to the interconnecting portion.

4. The line sensor apparatus according to claim **1**,
wherein the shape is provided on a main surface of each of the first light emission unit and the second light emission unit.

5. The line sensor apparatus according to claim **1**,
wherein the first light emission unit and the second light emission unit have respective end portion surfaces opposing with each other, wherein the shape is provided on each of the end portion surfaces.

6. The line sensor apparatus according to claim **1**,
wherein the first light emission unit has a first end portion and a second end portion along the longer side direction, wherein the first end portion is connected to the second light emission unit, and
in the first light emission unit, an amount of light emission from the second end portion is larger than the first end portion.

7. The line sensor apparatus according to claim **1**,
wherein the first light emission unit has a first end portion along the longer side direction which is connected to the second light emission unit,
the second light emission unit has a second end portion along the longer side direction which is connected to the first light emission unit, and
an end face of the first end portion has the same size as an end face of the second end portion.

8. The line sensor apparatus according to claim **1**,
wherein the lighting apparatus further comprises an elongated third light emission unit and an elongated fourth light emission unit each extending in a longer side direction and a shorter side direction,
wherein the third light emission unit and the fourth light emission unit have respective end portions in the longer side direction that are connected to each other via a restricting mechanism having a shape that restricts relative movement of the third and fourth light emission units in the shorter side direction,
wherein the third and fourth light emission units are located at the opposite side of the first and second light emission units across from the lens array, and

wherein the restricting mechanism of the first and second light emission units and the restricting mechanism of the third and fourth light emission units are located at different positions in the longer side direction.

9. The line sensor apparatus according to claim **3**,

wherein the connecting portions are holes each formed on the end portion of the first light emission unit and the second light emission unit.

10. The line sensor apparatus according to claim **5**,

wherein the first light emission unit has a raised portion on the end portion surface, and the second light emission unit has a recessed portion which engages the raised portion.

11. A reading apparatus comprising:

a line sensor apparatus comprising:

a casing,

a lighting apparatus,

a lens array configured to condense light irradiated toward an object from the lighting apparatus, and

a line sensor configured to detect the light condensed by the lens array,

wherein the lighting apparatus has an elongated first light emission unit and an elongated second light emission unit each extending in a longer side direction and a shorter side direction, and

wherein the first light emission unit and the second light emission unit have respective end portions in the longer side direction that are connected to each other via a restricting mechanism having a shape that restricts relative movement of the first and second light emission units in the shorter side direction, and

an output unit configured to output read data obtained by the line sensor assembly.

12. A printing apparatus comprising:

a reading apparatus configured to read a medium, the reading apparatus comprising:

a line sensor apparatus comprising:

a casing,

a lighting apparatus,

a lens array configured to condense light irradiated toward an object from the lighting apparatus, and

a line sensor configured to detect the light condensed by the lens array,

wherein the lighting apparatus has an elongated first light emission unit and an elongated second light emission unit each extending in a longer side direction and a shorter side direction, and

wherein the first light emission unit and the second light emission unit have respective end portions in the longer side direction that are connected to each other via a restricting mechanism having a shape that restricts relative movement of the first and second light emission units in the shorter side direction;

an output unit configured to output read data obtained by the line sensor assembly;

a printing unit configured to print on the medium based on a result of reading by the reading apparatus; and

a conveying unit configured to convey the medium.

* * * * *